MODELING PLASTICS INJECTION MOLDING OPERATION USING SIMULATION

TAN LI MEI

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ABSTRACT

Capacity planning plays a key role in the overall performance of an industries business and it is the new challenges for Malaysia manufacturing firms to maintain and practice it. In this study, a long series of discuss about the capacity planning in plastic injection molding operation using arena simulation software. Simulation as a decision making tool to evaluate the capacity utilization in term of worker and material use in the operation. Simulation tool simulate the current facility and to analyze and evaluate the operation's performance and determines the real factors measures to be undertaken in future to improve the efficiency of the plastic injection molding plant. The factors comprise the insufficient utilize of manpower, machines, and materials cause the running production slow and delay time for shipping finished goods to customers. Model will be developed in simulation software as same as real operation and test run to identifies the problems. Try-and-error to increase or decrease capacity of materials in duration of working time to the model will be tested several times in order to determine an improvement to enhance the operation. What-if analysis and scenario planning will be discussed by referring to the improvement model to identify the impact and provide better solution for future improvement.

Field of Research: Capacity Planning, Arena Simulation, Capacity Utilization, Plastic Injection Molding Operation

ABSTRAK

Perancangan kapasiti memainkan peranan penting dalam prestasi keseluruhan perniagaan industri dan ia adalah cabaran baru bagi firma pembuatan Malaysia untuk mengekalkan dan mengamalkannya. Dalam kajian ini, siri yang panjang membincangkan mengenai perancangan kapasiti dalam operasi plastik acuan sutikan menggunakanperisian simulasi arena. Simulasi sebagai alat membuat keputusan untuk menilai penggunaan kapasiti dalam jangka pekerja danpenggunaan bahan dalam operasi. Alat simulasi simulasi kemudahan semasa dan untuk menganalisis dan menilai prestasi operasi dan menentukan faktor-faktor sebenar langkah-langkah yang akan dilaksanakan pada masa akan datang untuk meningkatkan kecekapan loji acuan suntikan plastik. Faktor-faktor yang terdiri daripada tidak mencukupi menggunakan tenaga manusia, mesin, dan bahan-bahan yang menyebabkan pengeluaran masa yang berjalan perlahan dan kelewatan untuk penghantaran barangan siap kepada pelanggan. Model akan dibangunkan dalam perisian simulasi yang sama seperti operasi sebenar dan ujian dijalankan untuk mengenal pasti masalah. Try-and-Error untuk meningkatkan atau mengurangkan keupayaan bahan dalam tempoh masa bekerja untuk model yang akan diuji beberapa kali untuk menentukan peningkatan untuk meningkatkan operasi. Apa-jika analisis dan perancangan senario akan dibincangkan dengan merujuk kepada model penambahbaikan untuk mengenal pasti kesan dan menyediakan penyelesaian yang lebih baik untuk penambahbaikan pada masa hadapan.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Capacity planning is the strategy that identifies how many outputs is required from plant facilities and from suppliers. It is a process to determine the production capacity require by an organization. To meet forecasting demands of its product, compute needed capacity, develop alternative plans, evaluate capacity plans, select best capacity plans, and implement best plan. General concept for capacity planning is adding new capacity in advance of increasing demand. But it also will have the pro and cons if overload. Hence to implement an effective capacity planning, if the work load reach to maximum and organization able to complete in time due to constraint. The constraint may be quality standards, delay, and material handling, and so on. When the capacity is inadequate, the resulting shortages can lead to loss of customers and market share. This study will be proposed to analysis the performance of capacity planning for operation process in my research.

Today's world, plastics product account for about 80 percent of industry revenue and has play an indispensable role among manufacturing industry. According to Richard Reise (2009) The Plastics and Rubber Machinery Industry comprises establishments primarily engaged in manufacturing plastics and rubber products making machinery, such as plastics compression, extrusion and injection molding machinery and equipment, and tire building and recapping machinery and equipment (Richard Reise, April 2009). Hence, an extrusion and injection molding machinery and equipment process will be choose as operation process in order to finding the problem which encounter in the processes.

Simulation-based modeling is broadly recognized as powerful tools for people to analyzing, designing, and operation complex systems in manufacturing industry. It allows people to test hypothesis, model and forecasting performance of the real systems before developing costly implementation. According to a researcher Bin Han (2013), he said that simulation experiments based on historical data demonstrate the efficient performance of the approximation. The example model of Simulation include the finite element method (Kamnerdtong et al.2008; Liu 2000), scenario analysis in production systems (Choi et al. 2002; Pickardt et al. 2010), and discrete event simulation (Sharda and Bury 2010, Alexander 2006).

In this research will focus on the application of simulation by implement capacity planning in the plastics manufacturing industry. The SME Company that will observe is Junway Corporation at Penang which is a subcontracting company. Hence, in this chapter will discuss on using simulation model as a planning tool apply into the plastics injection molding process which needed by an organization to meet changing demands for its products. Simulation will use as an attempt to model the injection molding system and yield several scenarios and forecasting performance of the real life system before developing costly implementation.

Junway Corporation is subcontracting company which function as a "make to order" according to customer order quantity. Customer will provide materials as well as requirement on product design (mold tool, change of size, color, style, and appearance). It depends on the quantity and materials provided by customer and help produces the quantity of product by what customers provide for them. All of the plastics facility combined to produce billions of similar products per year in the market. On customer site, mostly customers expect to save cost on the production of products in order to gain more profit and reach breakeven for their sales in business. Hence, in order to help customer to produce more quantity than exact quantity as need, they need to assists customer to plan and produce more quantity with the limited material provided without affecting product quality and in low operation cost. For themselves, they need to plan on finding alternative way to audit overall cost from beginning till shipping out to customer and balance the level of capacity in the operation activity.

Nowadays, demand of the product increase, price and quality been issues, requirement from customer never stop, competitive with other competitors due the level of competition in plastics market is kept on increasing. Through my observation, the

practice for this company is they just "make to order" and didn't practice on "make to stock". Hence, companies also have to practice on make to stock through the implementation of capacity planning. To retain high utilization of capacity and ensures that customer order are met, when necessary, facilities will be able to support each other with product.

1.2 STATEMENT OF THE PROBLEM

The business use technology to maintain price and quality of product and profit margin in a highly competitive market and on the same time they need to find innovative and efficiency is becoming more competitive in plastics manufacturing industry. Hence, enterprises in plastics industry nowadays are become more responsive and aggressive to improve their performance to provide better service and product to maintain competitiveness.

Implementation of capacity planning is a challenge why a supply chain plan proves to be infeasible at the factory level, lack of sufficient resource capacity, material shortages, insufficient production lead time, and other constraints. Overload of capacity will cause the inventory level to rise or may underutilizing the factory's manpower and equipment, however too little capacity cause loss of customers to competitor. As a result, factory needs to balance between the demands places on an operation and ability to fulfill that demand. To implement an effective capacity planning is hard because of uncertainty in predicting future demand.

Basically, to set up an operation process, they need think on how the production run and to schedule time duration to produce products, machine available, cost to produce appropriate molds, manpower, processing or reprocessing, holding, shipping, and so on. However, when the issues come to material quality, machine shut down, customer requirement; the task is becoming complex and complicated. Based on the information by the operator given, he said the operations are divided into three departments which are injection molding, assembly, and warehousing in the facility.

There are 4 machines which perform the same function in the working area. The design of the product includes colors; material selection, appearance, and style are according to customer's approach. Facility is located nearly to the customer to reduce shipping cost. Mostly part of the working time is use for machine making time, and to produce one unit of plastics product need 1 minute. Manpower to handle the machine mostly is 1 person. Molding department run for five days a week, one day 6 hours, 1 hour will produce 60 units, and 6 hours are 360 units per day for one machine.

As the requirement becoming complex, demand forecast, capacity planning, material requirement, and quality become crucial. Another problems which face by

factory was the machine problem and cause process scrap, once the machine shut down, they need to take time to find out the problem and doing maintenance. It causes to delay the time to shipping out and unable to meet quantity expected by customer. So in this research will wish to suggest using simulation method to improve the performance of the process queuing system. Simulation modeling can be very accurately finds out the root problems in the process.

1.3 RESEARCH OBJECTIVE

The objectives of this research are:

1. To develop a model of the plastic injection molding operation using simulation.
2. To evaluate performance measures of the plastic injection molding operation.
3. To propose an improve process of the plastic injection molding operation.

1.4 RESEARCH QUESTIONS

1. What are the problems of capacity in the plastics injection molding operation?
2. Is the capacity level adequate to reach sizing capacity changes/capacity plan?
3. How does the simulation model help for better improvement for the performance of plastics injection molding operation in plant?

1.5 METHOD OF ANALYSIS

The measurement of process in research is to collect the relevant input data which were implemented with relevant process because it might be helpful for simulation model building. Simulation is an indispensible tool which has been applied by many field of industry to evaluate performance metrics for thousands of system-related activity to answer "what if" question. The accuracy of predicting system performance is determined primarily by the accuracies of the system design parameters and system workload. Hence, the selection of model parameters is essential as the modeling technique. Below are the major steps to build a simulation model:

1. Problem analysis and information collection: The preliminary step in developing a simulation model is to analyze what is the problem. This activity involves the identification of inputs parameters, performance measures of interest, linkage between parameters and variables, rules governing the operation of systems components, and etc. If the collection of information is enough, the problem can be examined and map out solution.
2. Data collection: Collect the relevant data from company for estimating model input parameters in the research. The analyst can help us to formulate assumptions on the distributions of random variables in the models. In addition, data collection also needed for model validation.
3. Model Construction: Problem is completely examined; relevant data collected, a first simple model is then develop and implement the analyst as computer program. For my research, a simple model will be construct which comprises of all facility in the operation process and put in the implementation of capacity planning.
4. Model verification: The objective of the model verification is to ensure that the model is conforms to its specification and does what it is supposed to do.
5. Model Validation: Process of determining the degree to which a model and its data are an accurate representation of the real-life system from the perspective of the intended uses of the model.

6. Designing and conducting simulation experiments: length of simulation run (run multiple times), number of runs (subject to different sequences different sequences of random numbers).

7. Output analysis: Use to estimate performance measures are subjected logical and statistical analysis.

8. Final recommendations: Final step, the output analysis draft out the recommendation for the system problem. Usually is belonging to the part of a documentation report.

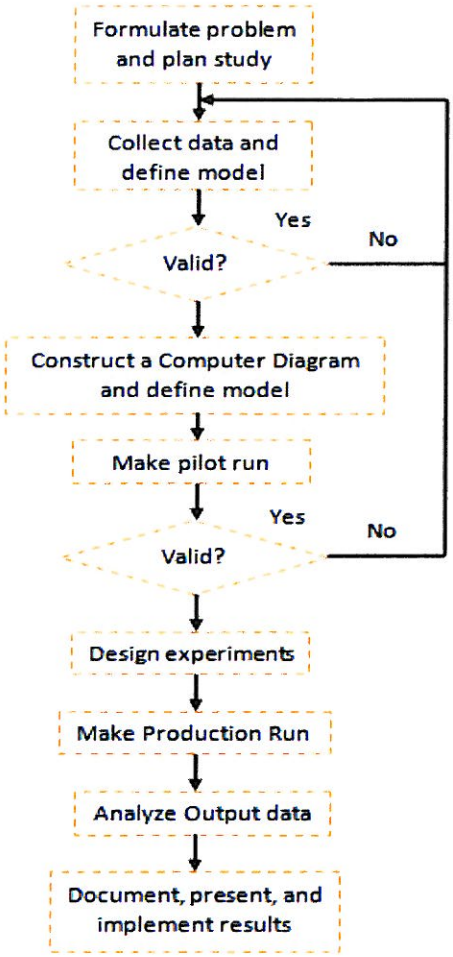

Figure 1-1 Simulation Steps

1.6 SIGNIFICANCE OF STUDY

The focus topic in this study is simulating the modeling process and analyzes and observes what if the implementation of capacity planning in plastics injection molding process. It will help to balance the level of capacity utilization not to overload or too little and enhance the efficiency the process. Apply simulation method in the operation process can help company to solve problem, control, save cost and time by create a model to examine what if analysis before developing costly implementation.

In the research, will significantly show how crucial capacity utilization affects the overall performance and the benefit of using simulation technology in plastics injection molding operation. In year 1982, most simulation software concentrated on material requirement planning (MRP) by only consider the timing and sizing or orders without regards to capacity limitations. Hundreds of robots and millions of dollars worth of computer-controlled equipment were worthless as they were underutilized and spent long time working on the wrong part because of poor planning. This study prove that how important to have a proper capacity planning in the facilities (Simulation and Modeling Team.d, 'IV. Introduction to modeling and simulation system', para. 21).

In chapter 2, a preliminary framework about measurement control and the chain between productivity, speed, and scrap as it related to the capacity planning in the activity will be outlined. In chapter 3, a production system and the model of measurement control will be illustrated and what is the limitation of the model also will be included. Chapter 4 is an expansion on the task from chapter 3. A simulation model will be develop, evaluate the performance though analysis of all related data collected, and talk over production losses and their implication on operation and requirement in the process. Chapter 5 will be a set of discussion on the simulation model experimentation and a recommendation to improve the overall process after the experiment. Observe the changes after suggesting experimental model into the operation system.

1.7 SCOPE OF STUDY

The scope of this research is to modeling a simulation model and to stimulate the process of plastics injection molding in Penang, Malaysia. Capacity planning, the activity of predicting the system performance for a given set of resource requirement to meet a desired level of performance will be used in plastics injection molding factory. The focus of this topic is using Arena simulation to create and test the model which is similar with the operation layout in real life. Arena will stimulate all probable results through combination of all probable input. Simulation model will test repeatedly and determine what the problem which will encounter in process. Redesign a new alternative model and experimenting with the new model to compare the results. The results will examine the level of capacity in the process, use of labor, machine utilization, and productivity, and finishing time. At last, a recommendation on improve the performance of plastics injection molding process which associated with the implementation of capacity planning to improve the performance.

1.8 OPERATION DEFINITION

Key Word	Definition
Capacity Planning Process	The production capacity by an organization to meet changing demands for its product, services, and business.
Capacity	The "throughput" or number of units a facility can hold, receive, store, or produce in a period of time.

CHAPTER 2

LITERATURE REVIEW

2 .1 INTRODUCTION

Capacity planning, any strategy used to determine the capacity needed to satisfy that demand for the goods and services produced by business (Tatum and Harris, 2014). Capacity, the "throughput" or the number of units a facility can hold, receive, store, or produce in a given time (Jay Heizer and Barry Render, 2011). It is critical to determine facility size in organization, with an objective of achieving high level of utilization and a high return of investment (Jay Heizer and Barry Render, 2011). In operation, the objective of capacity planning is to reduce discrepancy till minimum, for example provide a significant to execute the capacity level of resources, equipment, maintenance of production facilities, and size of manpower and maximize rate of output per unit of time. Purpose is to satisfy customer, so that customer have a steady supply of the products they demand. Simulation will use as an attempt in this research to study and improve the plastics injection molding operation.

2 .2 CAPACITY PLANNING

Advanced capacity planning practice in plastics injection molding operation help companies to balance capacity by reduces their inventories of finished goods to minimize the unwanted tied-up capital and to respond to fluctuations in demand. An imbalance capacity will cause hazardous for companies. The reason is if the capacity overload will results in low return on assets but if the capacity too little also can cause in lost sales which mean lost of customers. Hence the speed of react and flexibility in business practicing are dictating how successful a company can become today. Strategic network tools "capacity planning" enable companies to maintain supply chain responsive and supple while keeping cost in evaluate and turning out profitable solutions.

If companies are failing to manage these objectives, capacity imbalance will appear (Jonsson & Mattson, 2009). Anna Linne & Carl-Johan Ekhall, (2012) said the avoiding capacity imbalance are important since production resources available for adding vale are associated with costs, regardless if the resources are used or not. Capacity planning will apply into the plastics injection molding operation; the idea is to shape the approach to effective planning in adjusting the amount of production according to the demand for the product, both now and in upcoming production periods.

Effective capacity is an expectation for all firms to achieve given the current operating constraint. To manage capacity effectively, it is important that companies should always sensitive to any alteration to the changes of customers' preferences, required, purchase pattern, competitive among competitors, and condition of market. This is the initial step to gather all information in order to develop an effective capacity planning in companies. An effective capacity planning comprise of knowing how to determine when the system is out f capacity, what report to produce, and how often (Deitch, 2011). Charles C. Poireir (2012) said that the better forecasting is start with asking the right people with the right question. Hence for any such system to work effectively, the companies have to meticulously collect the necessary data from every department and person, who can generate valuable message about demand - internal sales representatives, customer service personnel, channel partners, distributors, customers and consumers.

Design a better capacity planning will enhance the process to make sure the right goods and services provided are available to meet the true demand. Many companies apply capacity planning as a tool to manage their facilities because it is a better approaches and procedures for order entry; order planning, and order management, and supply in order to reduce operating cost. To apply capacity as a tool for facilities, manager must address from indentifying bottlenecks, backup supplier, available alternate routings, contingency planning, actual cost, and impact of decision etc. To find out their actual impact on a variety of performance measures, including throughput capacity, inventory levels, and cycle times, before costly and disruptive changes are made.

A case study of a business process re-engineering project design advanced capacity planning together with scheduling software to both realize and manage the benefits of minimize customer lead times, lower inventory carrying costs and enhanced production/ material handling efficiencies. This case study was conducted for a plastic molding injection firm which has a high volume manufacturer of plastic product. The result of this project after design an effective capacity planning is dramatic. Finished goods inventory turns increased from 10 to 40, levels of WIP reduced from 60 million to 12 million items and production lead time have shrunk from weeks to days. This case study illustrate the successes by apply the concept for continuous improvement and customer service. An effective capacity planning can assist organization to yield significant efficiency and cost savings. (E.Mark Quinn, Waterloo-software.com, 2014)

Demand forecast always the best way in capacity planning process before costly implementation is made. Way of matching what companies can produce with customer demanded, and essentially balance the supply chain with demand chain. CNG Global Blog, (2013) stated that capacity's pervasive influence and the pace change make the need for accurate knowledge and flexibility a necessity. Capacity planning help companies to response quickly, while making educated and informed decisions, will direct impact to the health and success of organization. It also allows companies to rise above competition, compete based on organization supply chain and the service and flexibility that companies can provide to customer.

Simulation modeling is a sophisticated capacity planning technique which assists companies to simulate the queuing events that happen during execution.

Simulation modeling provides more deeply into the real system behavior during capacity planning. A case study from Ron Shaw of Muelleur Industries is enthusiastic about the benefits of using simulation as capacity planning techniques to manage their facilities. The result after getting use of this capacity planning technique was the company builds the simulation which confirms that the plant in its current configuration does not have the capacity required to process the amount of scrap that the company had initially planned for. Hence, the current conditions are costing them in the neighborhood of 7 million. Having concrete evidence of the reason why will allow them to correct the situation and plan alternative uses for the casting plant. This company is continuing to expand the role that simulations play on its organization to support better operating decision making. (SIMU8, 2014)

2 .3 SIMULATION

Simulation is an alternative method of analyzing systems which used across many industries to model random events, such as simulated outcomes closely match real-world outcomes to design a better capacity planning process in production system. By observing simulated outcomes, researchers gain insight on the real world. Simulation is very advanced to researcher and also to companies because it may approximate real-world results; yet, require less time, effort, and/ or money that other approaches. Refer to the news of Today's Medical Development dated April 2, 2014, Daebler highlighted that industrial users will find everything they need to create highly realistic simulations of their future products and production processes.

Simulation act as an education to create a learning opportunities and experiences for engineer, researcher, and students, designer to study the model of real world situations, allowing for strong transfer and development of understanding to the real system. Simulation study has in a range of overlapping areas, including fluid dynamics, load analysis, process timing and sequencing, the selection of assembly and production processes, calculating service life and stability, and product licensing and certification processes. Simulations "transformation has serious implication for people in the space of education and nearly all institutions- business, industry, medicine, science, and

government- have harnessed aspects of these simulation technologies (Klopfer, Osterweil, Groff, and Haas, 2009)

Simulation is broad use by profession from variety of working and research area for practicing. A survey which conducted in year 2010 by Association of America Medical Colleges proved that more than 85% of the 90 participating medical schools and 64 teaching hospitals use simulation across the medical residency for subspecialty clinical fellowships, and nearly 68% use simulation for practicing physicians. A response from the 115 medical simulation centers (of 700 centers invited) in a 2010 survey indicated that medical schools had the highest annual operating costs for their simulation centers. However on the other side, a systematic review of 109 articles, Issenberg et al. summarized that high-fidelity medical simulations positively affect learning under the appropriate situations, for example providing feedback, individualizing learning and simulators, and repetitive practice. (Lazzara et al., 2014)

Simulation is the best tool for many projects since there is no one proper tool to solve the project's problem. In case of using wrong tool will more damage than good. Ilar,T, (2008) have been cite for several authors which discussed about successful simulation project. Simulation success provides the right information at the right timing which as people needs to make right decision. Sadowski defined a successful simulation project as one "that delivers useful information at the appropriate time to support a meaningful decision." However, Robinson and Pidd, apply this ideas and propose a four stage model of simulation project success which shown in figure 2 -1. A typical time span from the beginning stage of the study to when results from the implementation are available can be several years.

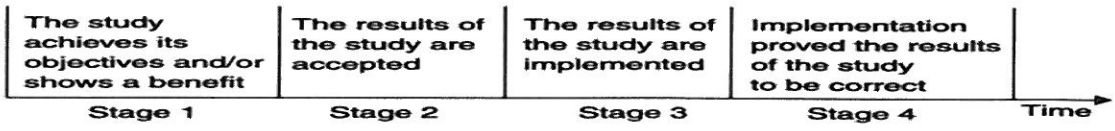

Figure 2 -1 Four Stages model of Simulation Project Success (Robinson and Pidd)

Discrete event simulation (DES) is an operational research for researcher to analysis, planning, design, and operation. Production simulation systems are belonging to a group of discrete event simulation software packages specially designed for the representation of manufacturing system. Refer to the paper being presented in 2013 Winter Simulation Conference; they concluded that "DES is a technique used

extensively and effectively by large companies; however it is not widely used by small to medium sized enterprises (SMEs) due to complexity and related costs being prohibitively high." The nature of DES model (data gathering and preparation phase) is where complexity and effort required are highest in order to avoid the potential erroneous results due to incorrect assumed or real input data. Hence, a solution is being proposed to minimize the barrier for SMEs to gain benefit from DES due to reduced complexity and effort. The solution is a Cloud-based adapter that able to identify and link to defined problems scenarios. (Byrne, Byrne, Carvalho e Ferreira, and Ivers, 2013 Winter Simulation Conference)

Simulation is a planning tool associated with operational research to support strategic decision making. Simulation can be use to model business process and optimize supply chain. Business process simulation (BPS) is an instrument for reducing the risk associated with strategic change. BPS assist business analysts and stakeholder to determine prospective processes, refine, and select among alternatives. Mostly is used to evaluate dynamic behavior of processes over time, for example the development of process and resources performance in reaction to alter or fluctuations of certain system parameters. Kumar and Bhat (2009) make a conclusion in their case study that process simulation not only can use by business analyst as a design time tool but it also can be used operational managers in runtimes environment. Many business problems are suitable for simulation including designing capacity planning, warehousing location, processes outsourcing/ relocation, supply chain, and etc.

Simulation tools available can be overwhelming for new users. A group of business process simulation tools comprises of Arena, Protos, ARIS, FLOW *er,* FileNet, and CPN tools. Arena model will be presented in this research. Arena model has been widely used in both industry and academia. Arena model is very easy to developed and mostly uses as working simulation environment. It is a simulation tool developed by Rockwell Automation. Arena provides standard statistics for all performance indicators specified. For each statistic, the minimum and maximum value is given, as well as mean and half length of the 95% confidence interval. (Jansen-Vullers and Netjes, 2006). Arena Simulation Software has become one of the most popularity topics which discuss by Simulation users all around the world.

Arena users representing 15 different countries and 56 unique organizations gathered for an incredible mindshare event highlighting the benefit of simulation –

ArenaSphere 2012. Arena 14, latest release including 3D animation in year 2012 has the most advanced 3D animation environment in the discrete event simulation industry. However in year 2014, Arena upgraded to a new version 14.5 which the Visual Designer tool provides realistic in-process 3D animation of conveyors and transporter. As 28 January 2014, there is a news report about new plan for implementing of arena "The Sacramento Kings release renderings of their planned new downtown arena to season ticket holders and issuing a press release. James Herbert reported according to The Kings speech, the downtown plaza will be "as much of a focal points as the arena," according to the Sacramento Bee, and people will be able to look inside the arena of the plaza.

2 .4 SIMULATION APPLICATION IN INDUSTRY

Over the years, government and industry are working independently with new technologies and hardware, created a broad range of products and linked application to enhance simulation science. Today Simulation is one of the most multifaceted topics that can face an Industrial Engineer in the workplace. It can also be one of the most important to a corporation, regardless of the industry. Quality, safety and productivity are all affected by Simulation, whether the issues happen in the office, on the manufacturing floor, or in a warehouse. (Simulation and Modeling Team.d, 'IV. Introduction to modeling and simulation system', para. 1).

In 12 February of 2014 there is a news from "Charles Sturt University (CSU)", a research has found that the use of simulations able to aid police training in NSW for better prepares both new and experienced officers for the 'real world'. "The VirTra simulation uses surround screens". While there is typical environmental sound, landscape and dialogue of typical interaction between police and members of the public, there are no typical environmental smell elements replicated and the officer cannot 'touch the characters depicted on the screens. Learners require simulation characteristics which at minimum engage sight and hearing in replicating the real word as closely as possible. The finding from the research have implication for the NSW police in the future design and development of simulation based training for police recruit training and operational police training initiatives. (Dr. Davies, 2014)